Optimal Design of Multiport DC/DC Converters for Hybrid Systems

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Introduction

Hybridization enhances system performances by combining the advantages of different sources:

	FC	Battery	UC	Genset
Efficiency	+	++	++	-
Energy density	+	-	--	++
Power density	0	0	++	++
Dynamic performances	-	0	++	++
Cost	-	0	-	+
Emissions	+	++	++	--
Noise	++	++	++	--
Fueling time	++	-	-	++
Availability of the energy source	--	++	++	-
Infrastructure	--	0	0	++

A Power Electronic Interface is required to regulate the voltage source to the output voltage level. A solution is to combine all the different sources to a common power converter (**Multi-Port Converter**).

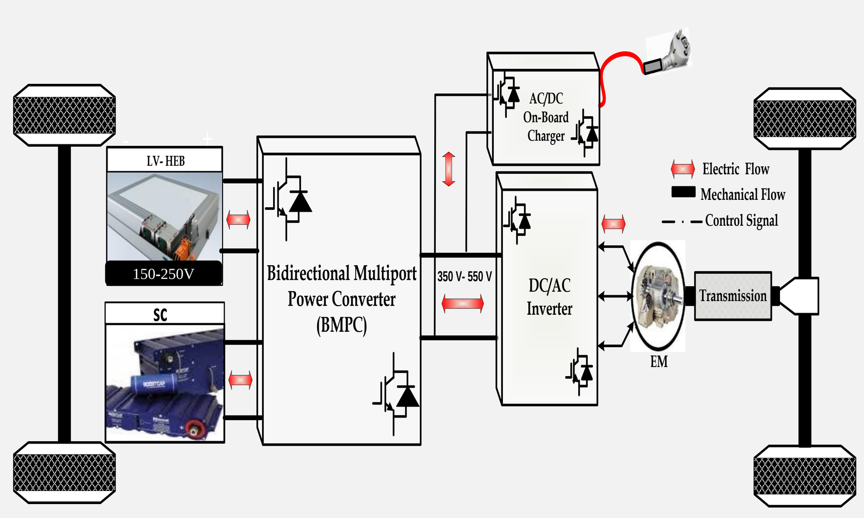


Fig. 1 BEV Powertrain with LV battery and UC (Hegazy et al., 2014).

Interleaved Multiple-Input Port Converter

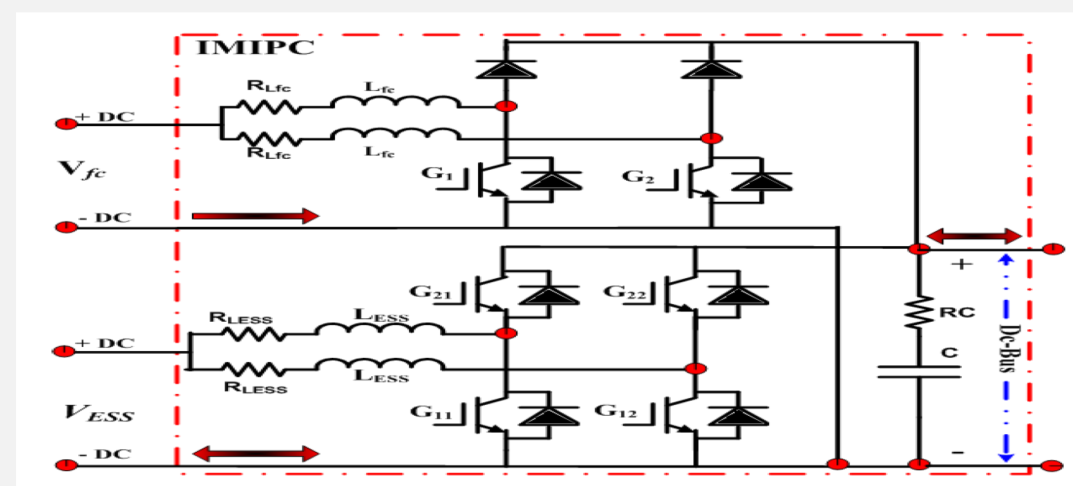


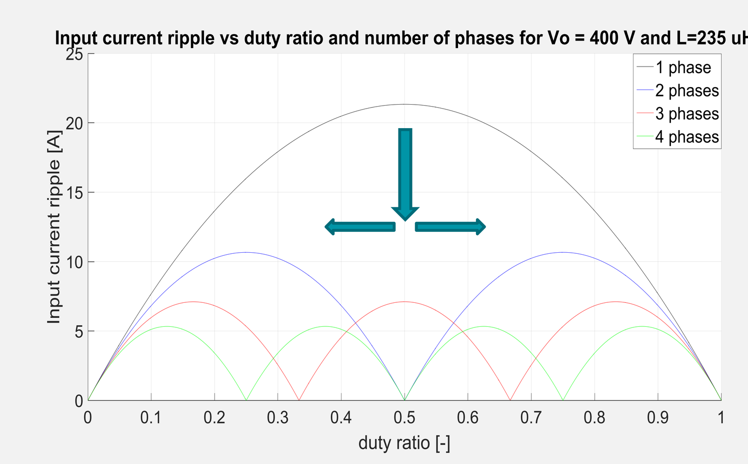
Fig. 2 Interleaved Multiple-Input Port Converter (Hegazy et al., 2011).

- ✓ Lower input ripple
- ✓ Higher efficiency
- ✓ Reliable topology
- ✓ Compact packaging
- ✓ Centralized Control
- ➢ Weight & Cost?

- ✘ Complex Control
- ✘ DCM at higher power
- ✘ EMC → @ DCM

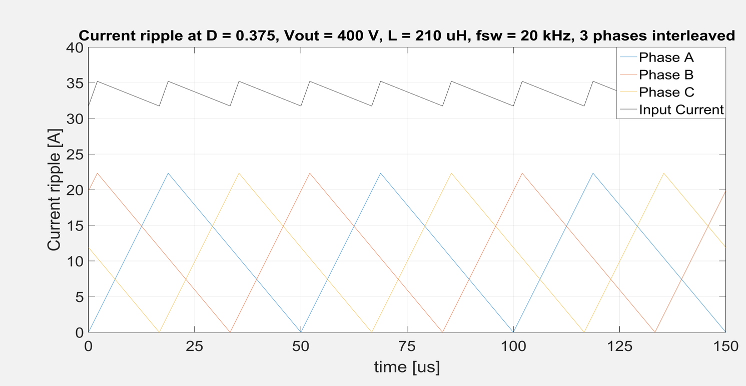
Interleaving phases has an impact on the input current ripple

For a single phase inductor the maximum input current ripple occurs at D=0.5. With the interleaved technique, the maximum current is decreased, but the peaks are shifted in the duty ratio region.



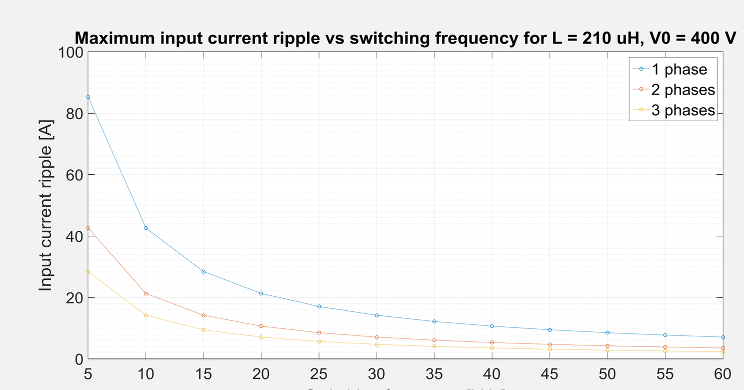
Less input current ripple is achieved

Due to a proper shifting of phases the input current ripple is decreased. However, the harmonics have a higher frequency which may cause EMC issues.



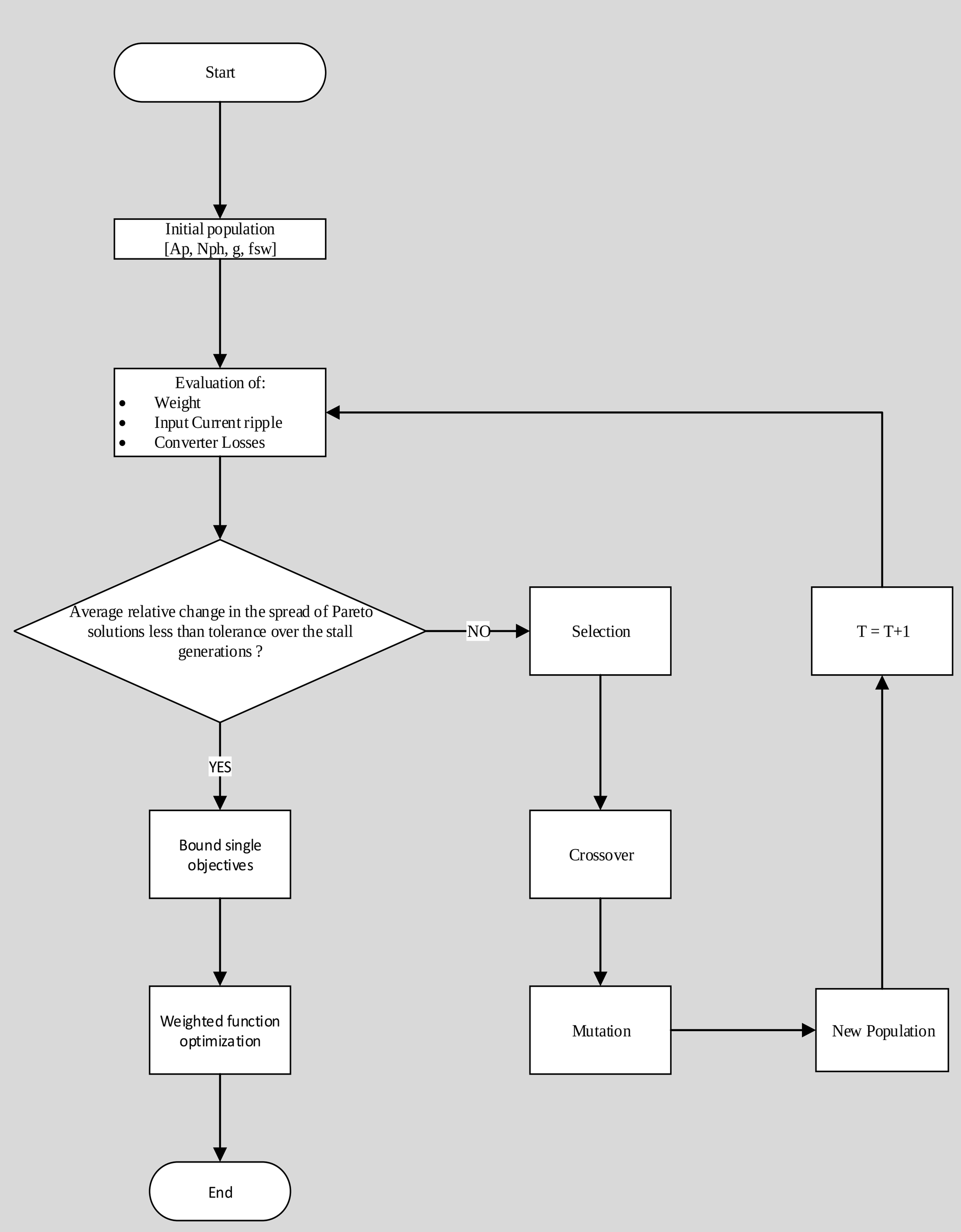
What about with SiC/GaN technology?

SiC/GaN technology allows to achieve higher frequency with a consequent current ripple decrease. A design optimization is required to evaluate the best trade-off in terms of inductor size, number of phases and switching frequency.



IGBT(Si) → SiC/GaN

Multi-Objectives Genetic Algorithm Design Optimization



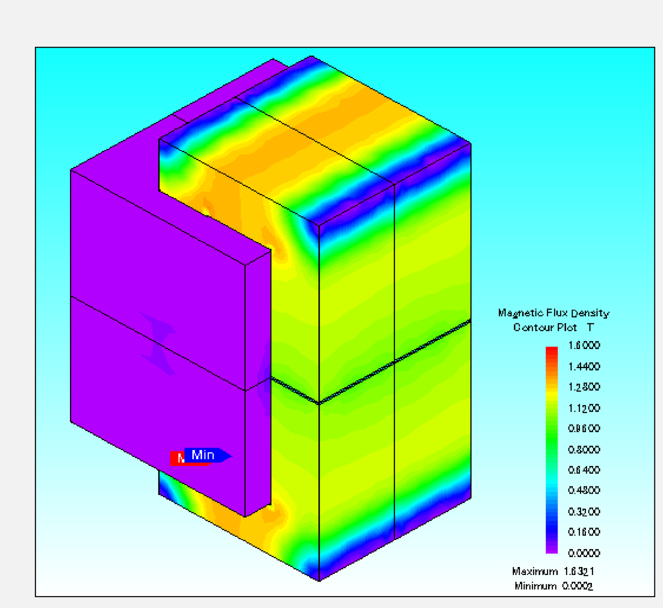
Conclusions

- Several **Multi-Port Converter** topologies have been investigated to find out the best topology for **automotive** applications.
- The **Single Port DC/DC converter** has been analysed with a focus on the impact of the **Interleaving** technique on the input current ripple.
- A **Multi-Objectives Genetic Algorithm Design Optimization** is performed with the aid of Ap values in inductors' datasheets.

Future work

Detailed Losses model

- Current FEM model uses empirical losses law based on **Epstein** test (sine wave current).
- Inductors for DC/DC converters bears high DC bias current that will saturate the material and the empirical losses are not more valid.
- DC bias current tests.



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